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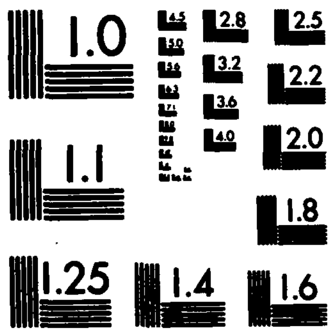

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AFCRL ACOUSTIC WIND SENSOR SYSTEM

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Final Report for Period 10 April 1973 - 3 July 1974

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13. ABSTRACT

A remote wind measuring system is a useful analytical tool for meteorological studies. Advantages over tower-mounted sensors include a higher degree of portability, less maintenance, and the absence of a structure which would modify the velocities by its presence. A description of the successful design, fabrication, and testing of such a system is given.

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I. INTRODUCTION

This final report concludes a program to design, fabricate and test a remote acoustic wind sensor system. The technique of observing acoustic signals scattered from naturally occurring atmospheric inhomogeneities and the subsequent analysis of the doppler velocity spectrum to measure the ambient winds has been developed by Xonics personnel over the past three years. The results of this effort are manifest in the remote acoustic wind sensor recently delivered to the Air Force Cambridge Research Laboratories. This system incorporates remote, three-dimensional, real-time wind profiling over the altitude interval of 15 to 180 meters. The system is capable of routine operation over a broad range of environmental conditions and measurement of wind velocities up to 8 m/sec with a resolution of 0.5 m/sec.

This final report summarizes the various tasks completed under the Department of the Air Force Contract Number F19628-73-C-0201. The statement of work called for the design, fabrication, testing and documentation of an acoustic wind sensor. The results of this effort and their implications on future work in the area of remote acoustic sensing are the subject of this report. Section II summarizes the objectives of the program. Section III describes the work done to implement these objectives, and presents the test results. Section IV discusses the implications of the tests and the conclusions.

The personnel responsible for the effort represented here were:

Dr. Martin Balser	Senior Vice President, Systems & Engineering Division
Dr. Charles McNary	Manager, Acoustic Sensing Group
Frank E. Ambler	
Dennis Anderson	
David Eby	
Donald Knowles	
Arthur E. Nagy	
Kenneth Orcutt	
Jack Swoboda	

Recognition must also be given to Dr. Chandran Kaimal and his associates at AFCRL whose attention and cooperation not only made the effort efficient, but pleasant.

II. OBJECTIVES

The objectives of the program were to design, fabricate and test an acoustic sensor which will be used to remotely measure wind profiles in the lower atmosphere. It was to be designed to meet the following specifications:

Altitude range:	15-180 meters
Number of points in profile:	10
Wind speed range:	0-8 mps
Wind speed resolution:	0.5 mps

The fabricated product was to be tested in the laboratory and in the field to demonstrate satisfactory operation. The laboratory tests were designed to verify proper operation of the signal processing subsystem. The atmospheric test plan was designed to provide AFCRL personnel with actual "hands on" experience with the sensor operation, and to verify operation by comparison of the results with sensors of known accuracy.

III. PROGRAM EFFORT

The work performed on this contract can be logically divided into three phases, which were: 1) Design; 2) Fabrication; and 3) Testing. In addition, data were generated in the form of reports, which included:

1. Design Specifications for the AFCRL Wind Sensor System, 12 May 1973;

2. Test and Acceptance Plan for the AFCRL Acoustic Wind Sensor System, A. Nagy, October 1973;

3. R&D Equipment Information Manual and Software Description for the AFCRL Wind Sensor System, Xonics Acoustic Sensing Group, April 1974.

The results of the design effort are contained in the "Design Specifications for the AFCRL Wind Sensor System." In summary, the system consisted of one transmitting antenna, three receiving antennas, and a signal processor. The transmitter was composed of an array of nine acoustic drivers driven in phase at 8 kHz producing a vertical beam of four degrees beamwidth. The receivers were simple parabolic reflectors with shields to minimize sidelobes and a microphone at the focus to provide a fan beam which was narrow in the azimuthal dimension and broad (about 40 degrees) in elevation sensitivity. The signal processor performed a digital Fourier transformation of 64 time samples of each receiver output at each altitude, detected the doppler shifts, transformed these shifts into orthogonal velocity components, and printed the results on a teletypewriter.

Laboratory and field tests followed completion of the fabrication effort. The laboratory tests were designed to verify processor operation, and consisted of replacing sensor signals with sine wave voltages from an oscillator. The expected results were controlled by changing the input frequency which thereby simulated doppler-shifted receiver outputs. These tests were successfully completed and the system was shipped to the *Air Force Cambridge Research Laboratories* in Bedford, Massachusetts.

The system was installed and data were taken. The chosen site limited the transmitter-receiver separation to about 100 meters so that profiles were limited to about 100 meters in altitude. Data was simultaneously taken with an AFCRL sonic anemometer located on a tower which was 18 meters high and about 60 meters away.

The atmospheric tests showed a tendency toward low readings at the 15 meter altitude, but excellent agreement when higher altitude readings were extrapolated and compared with the reference anemometer. Direct reflections from a nearby structure were suspected as a cause for the low altitude velocity discrepancy. More extensive testing would be necessary to confirm this.

IV. CONCLUSIONS

On the basis of the laboratory and atmospheric test results, the acoustic wind sensor system appears to operate satisfactorily. The system operated reliably and consistently with a minimum amount of interference from other acoustic sources.

Unique design features of the system include the multiple-element transmitter array, effective acoustic shielding to minimize transmitter sidelobe propagation and single-microphone receivers providing extended, sharply defined elevation coverage along with very narrow azimuthal beamwidths. The sharply defined beams and good sidelobe suppression are the result of integrating the microphone feed horn design with the receiver shield design. In summary, the basic component designs for this wind sensing system are simple, and the excellent system operating characteristics are the result of extensive effort in component and subsystem integration into the operational wind sensor.

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